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Test Report for SCBA Hoses

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Test For Mustard (HD) Liquid Challenge
of Hoses for Self Contained Breathing Apparatus (SCBA)

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PREFACE

The work described in this report was authorized under the Expert Assistance Program for CBDCOM Program Director for Domestic Preparedness. The use of trade or manufacturers' names in this report does not constitute an official endorsement of any commercial products. This report may not be cited for purposes of advertisement.

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DOMESTIC PREPAREDNESS PROGRAM: MUSTARD (HD) LIQUID CHALLENGE OF HOSES FOR SELF CONTAINED BREATHING APPARATUS (SCBA)

1. INTRODUCTION.

Under the Domestic Preparedness (DP) Expert Assistance Personal Protection Equipment (PPE) Evaluation Program, the Chemical Biological Center (CB) was tasked to perform testing of hoses for Self Contained Breathing Apparatus (SCBA) against permeation by liquid mustard (HD). HD is a military chemical agent whose action is vesicant (blistering). It is used as a standard permeation test challenge because it permeates most protective materials more rapidly than any other chemical agent, thus shortening the test time to detection of permeation. The DP Program includes response to incidents of military chemical agent, thus shortening the test time to detection of permeation. The DP Program includes response to incidents of military chemical agents dispersed in a civilian setting, therefore the requirement for testing responders' personal protective gear against these agents. If the components of the PPE resist HD permeation for a specified time, it is certain that the components will resist permeation by any other chemical agent for the same time. The actual permeation testing was assigned to the Chemical Evaluation Laboratory, Surety Team, Engineering Directorate, which has many years experience in testing military breathing hoses against HD, using a standard method. The requirement for test results was given to the laboratory as one hour resistance to HD permeation. The purpose of the test was to collect data on the performance of the hoses against HD challenges.

2. METHODOLOGY.

2.1 Mustard Permeation Test.

The mustard permeation test used in this study is based on the following references:

- a. MIL-STD-282, 28 May 1956, Department of Defense Test Method Standard, Notice 4, Filter Units, Protective Clothing, Gas-Mask Components and Related Products: Performance Test Methods, Method 204.1.2 Mustard Resistance of Impermeable Materials (Static Diffusion Method).
- b. SOP CR9-ISP011-96C Testing Resistance of Impermeable Material Hoses to Mustard (HD), VX, TGD, and HD Simulant

- c. MIL-H-14506 Hose: For Filter Units
- d. EA-H-1350 Hose for Chemical Biological Aircrew Mask XM43

MIL-STD-282 provides all the details of the HD permeation test, but does not specify how to test odd items such as hoses or irregularly shaped items, nor does it specify how long items should resist HD permeation. These requirements are provided in military specifications and purchase descriptions, such as MIL-H-14506 and EA-H-1350, and in laboratory SOPs. This study used the provisions of MIL-STD-282, MIL-H-14506, and EA-H-1350 without modifications, and the testing was performed in accordance with SOP CR9-ISP011-96C, which covers all steps of the operation and all safety precautions necessary. The safety precautions include such things as performing the operation inside a certified fume hood, wearing butyl rubber gloves when handling HD, use of a protective mask, appropriate decontamination procedures for the agent involved, and authorized disposal procedures.

2.2 Test Method. Mustard permeation testing is performed in test apparatus Q170, which is a closed box with thermostat controls, at a temperature of 37°C. An internal fan circulates the air to maintain the temperature, and a bed of Whetlerite (activated, impregnated carbon) is used to adsorb any HD vapors that escape into the chamber. The test items are placed on glass trays that divide the chamber into upper and lower portions. A window is installed in the wall of the lower chamber through which the underside of the test items can be observed by means of a slanted mirror in the lower chamber. Indicator paper in intimate contact with the underside of the test item indicates when HD has permeated the item. The indicator paper is made by dipping filter paper (NNN-P-1475B) into an aqueous solution of congo red dye (0.1%), allowing to dry, and storing in an acid-free environment until required for use. To use, drops of S-328 solution are placed on the paper, allowed to dry, and the prepared paper is placed under the test item such that the S-328 drops are at the spot where HD is expected to permeate the item. When HD contacts the S-328 spots, blue spots form; the reaction is HD reacts with S-328 to form hydrogen chloride (HCl), which reacts with congo red dye to turn the dye blue. S-328 is tetrachloro-7,8-diphenylglycouril; it is dissolved in tetrachloroethane (0.5 gm S-328, 0.1 gm sodium carbonate in 10 mL), and the solution can be used for 2-3 days after preparation. The S-328/HD/congo red reaction is sensitive to a permeation of mustard vapor of $4\mu\text{g}/\text{cm}^2$.

2.3 Test Operation. Prepare the hose specimen by cutting a 6-inch section from the hose. Plug one end of the specimen with an impermeable plug (e.g., a short section of Plexiglas rod machined so as to be inserted tightly into the bore of the

hose). Wrap a strip of indicator paper tightly around the hose specimen and secure it with rubber bands so that the paper is in intimate contact with the surface of the hose. If the hose is corrugated, use a streak of the S-328 solution instead of dots on the congo red paper to assure that the hose will contact the S-328. Lay the specimen in a holder in the horizontal position such that the S-328 (streak or dots) is on the underside. Use a long tip Pasteur pipet to place a 3-4 inch line of liquid mustard inside the hose (indicated by the length of the pipet emerging from the bore). Plug the second end of the hose. Place the holder with hose specimen on the upper tray of the Q170 test apparatus and close the door. Start a timer when the HD is placed inside the hose. Observe the congo red indicator paper through the window and mirror for the appearance of blue color, which indicates that HD has permeated the wall of the hose specimen. Terminate the test when a blue color appears, or at one hour, whichever occurs first.

2.4 Test Parameters and Observations. The HD used in this test was a high purity distilled mustard, certified by CB, Research and Technology Center for purity and for use as a CASARM (Chemical Agent Standard Analytical Reference Material). The temperature controller and readout for the Q170 test apparatus was calibrated in accordance with DOD regulations. Liquid mustard is a more severe challenge than mustard vapor, and will permeate the challenged material much sooner. Thus, using liquid HD is a more conservative test. It is not anticipated that these hoses will be used in an environment where contact with liquid HD is possible; indeed, manufacturers' instruction manuals state that these systems (SCBA) are not for use in atmospheres Immediately Dangerous to Life or Health (IDLH), or where oxygen levels are less than 19.5 percent. IDLH values have not been established for HD, since workers will already be required to wear these types of respiratory protection at concentrations much lower than what is considered IDLH for HD, due to concerns over carcinogenicity. It is required that mustard agent concentrations and projected stay times are such that emergency response personnel using SCBA systems will not exceed the Airborne Exposure Limit (AEL) of 0.003 mg/m^3 , which is a ceiling value referring to the maximum exposure concentration at any time, for any duration (AR385-61, para 2-5, n (2) and Tables 2-2 and 2-3). Performing the test at 37°C is also conservative, since permeation rates increase linearly with temperature, and the SCBA will most likely be used at or near room temperature (25°C). The hoses are not inspected for pinholes, discontinuities, flaws, or other imperfections, since the permeation test is designed to detect pinholes as well as ease of permeation, and the samples submitted for test presumably were randomly sampled and represent the items available to the public. Also, quality assurance procedures in place at the manufacturing plant will presumably have inspected and rejected hoses that did not meet physical requirements, including wall thickness, discontinuities, and other flaws. The permeation test for hoses requires that the HD be placed inside the hose, rather than on the outer surface as would occur in

an actual contamination. This is done for convenience, since HD liquid placed on the outer surface would run off, or would have to be placed in a pool under the hose where it would be subject to evaporation, thereby gradually reducing the total challenge. Detecting permeation inside the hose is also problematical and would needlessly complicate the test. A pool of liquid HD inside the hose will be a driving force for permeation directly through the hose wall to the point where the S-328 indicator is located. HD that migrates to other sections of the hose wall, including wicking through any fabric embedded in the polymer, would have no effect on the permeation rate because of the relatively large quantity of challenge HD compared with the quantity that actually permeates and is detected on the indicator paper.

3. MATERIALS, REQUIREMENTS, AND TEST RESULTS.

3.1 Test Hoses.

Seven SCBA hoses from each of six manufacturers were provided for the test. The manufacturers and SCBA hose identification are as follows:

Racal™ Safety and Health	Assembly, Low Pressure (36Z-16-56R01)
Survivair®	Low Pressure Assembly (910647)
Mine Safety Appliance	Flexible, corrugated, Hose
Interspiro	Hose, Breathing, w/Bypass Valve
Draegar Safety, Inc.	Evolution, with Hose
Scott Aviation Health & Safety	Assembly, Low Pressure, E-Z Flo

3.2 Requirements.

The permeation requirements were as follows:

Table 1. Permeation Requirements

<u>Sample Size</u>	<u>Temperature °C</u>	<u>Mustard Challenge, gm</u>	<u>#Samples</u>	<u>Hours Required</u>
6 inch	37	0.5 – 0.7	7	1

3.3 Results.

The test results are presented in Table 2.

Table 2. Permeation of Hoses by Liquid Mustard

<u>Sample Tested</u>	<u>Requirement, Hour</u>	<u># Tests</u>	<u>Results, Hours</u>
Racal Safety & Health (36Z-16-56R01)	>1	7	>1
Survivair (910647)	>1	7	>1
Mine Safety Appliance, Flexible Corrugated Hose	>1	7	>1
Interspiro, Breathing Hose with Bypass Valve	>1	7	>1
Draeger, Safety, Inc., Evolution, with Hose	>1	7	>1
Scott Aviation Health and Safety, E-Z Flo	>1	7	>1

4. CONCLUSIONS.

4.1 Summary.

For each manufacturer, seven individual hoses were sampled and one permeation test run on each, for a total of 42 tests. The test requirement was for no permeation of HD to occur before one hour of exposure to liquid HD. Each sample tested resisted permeation to HD for at least one hour. It is concluded that each type of hose tested will meet the requirements for use in an HD-contaminated atmosphere where Self Contained Breathing Apparatus is authorized to be used.

4.2 Recommendation.

The hoses for the Self Contained Breathing Apparatus tested as indicated in this report will resist permeation by large quantities of liquid mustard and are qualified for use on operations where there is potential exposure to liquid or vaporous mustard for at least one hour.